DJAS
Damietta Journal of Agricultural Sciences
مجلـة دميـاط للعلـوم الزراعيـة

# Damietta Journal of Agricultural Sciences

Volume 2, Issue I, 2023

Damietta Journal of Agricultural Sciences
http://publication.du.edu.eg/journal/ojs302design/index.php/agr/index
ISSN: 2812-5347(Print)- 2812-5355 (Online)

# Manufacturing and Performance Evaluation of a Simplified Machine for Peanut Shelling

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**ARTICLE INFO**

*Key words:*
*Peanut*
Shelling
Efficiency
Energy
Operational cost

## ABSTRACT

The experiments were carried out to develop and construct a local shelling machine for shelling peanuts. The main parts of the peanut shelling machine were as follows: feed hopper, shelling chamber, shelling drum, concave sieve, blower, and electrical motor with transmission pulleys and V-belts. The performance of the developed machine was studied under the following parameters: three different drum speeds of (300, 400, and 500 rpm) corresponding to (3.45, 4.6 and 5.75 m/s); three different peanut moisture contents of (8.96, 12 and 15.61%); and three different feeding rates of (60, 90 and 120 kg/h). The performance of the manufactured shelling machine was evaluated, taking into consideration the following indicators: machine productivity, breakage percentage, shelling efficiency, cleaning efficiency, consumed energy and operational cost. The experimental results reveal that the highest value of machine productivity was 50.28 kg/h while the lowest values of both consumed energy and operational cost were 9.98 kW.h/Mg and 343 L.E/Mg were obtained at drum speed of 400 rpm (4.6 m/s), moisture content of 8.96% and feeding rate of 120 kg/h. The highest value of cleaning efficiency was 98.8%, while the lowest value of breakage percentage was 2%. These values were obtained at a drum speed of 300 rpm (3.45 m/s), moisture content of 15.61%, feed rate of 60 kg/h; and constant air speed of 10.6 m/s. The shelling efficiency was 100 % under all machine test runs.

## 1. INTRODUCTION

Peanut (Arachis hypogaea L.) is a major oil and food crop farmed primarily for oil (seed oil 43-55%) and protein (seed protein 25-28%) production, **Hosseinzadeh et al. (2009)**. The crop is grown primarily for human use and has a variety of applications, either as whole seeds or as a processed product used in peanut butter, oil, and other items. Peanut is one of the important summer plants in the newly reclaimed soils in Egypt, which are often sandy or light-yellow lands. Peanut make a quick benefit return for the farmers, so they preferred to grow it on these lands. Peanut is an important export crop with about 65-70% consumption of domestic production, **Fageria *et al.* (1997)**. As a cash crop, it is extensively traded locally, regionally, and globally contributing significantly to rural household income and national economic money in Africa.In Egypt, the cultivated area was 64000 hectares with a total yield of 213.777 Mgs. Globally, peanut is grown on 31.568 million hectares, with a total annual production of 53.638 million Mgs, **FAO (2020)**. Francisco and **Resurreccion (2008)** reported that peanut shells are frequently added to processed goods like peanut paste and peanut butter to extend their shelf life and increase their antioxidant and nutritional value. It has been demonstrated that phenolic acids protect against oxidative damage disorders such as coronary heart disease, stroke, and many types of cancer. **Mungase et al. (2016)** devised and built a machine in which bicycle sprockets are turned by pedaling action and this rotational motion is employed to move the shaft of a screw conveyor. The peanut is crushed between the flights surrounding the shaft and the conveyor case. Considering all of these concepts, equipment was created that is inexpensive in cost and maintenance yet high in efficiency. **Kingsley *et al.* (2018)** designed and manufactured a portable dry peanut peeler electrically powered by a 1 hp electric motor to reduce the rigors encountered by the traditional (manual) peeling method while maximizing the production of good quality peanut seeds. The performance result shows that the peeling efficiency and capacity of the machine are 92.14% and 36.12 kg/h, respectively. The peanut shell peeling capacity of approximately 35 kg/h, with the percentage of split shells at 35% and compared to the manual method producing only 4.2 kg/h/person. **Helmy (2001)** designed, built, and evaluated an alternative sheller to study the effect of certain operational parameters on the shelling of peanut from pods. He concluded that the shelling efficiency of peanut was 95.44% at about 17.12% d.b moisture content when the sieve box speed, headspace, and feed rate were 1.4 m/s, 18 mm, and 80 kg/h, respectively. The lowest total cost value of 64 L.E/Mg was obtained under the same operating conditions.

This research aimed to manufacture and evaluate the performance of a simplified machine for peanut shelling to encourage large-scale manufacturers and entrepreneurs to increase the production of peanuts and thus increase the local income, with the possibility of exporting to provide hard currency. The peanut shelling machine will be available on the local market at an affordable price that most small-scale farmers can afford and will be maintained easily, eventually replacing the traditional peanut shelling methods. Thus, the objectives of this research are to develop and manufacture a simplified machine locally made for shelling peanut, determine the most appropriate operating parameters affecting the peanut shelling process and evaluate the developed peanut shelling machine economically.

## 2. MATERIAL AND METHODS

This study was carried out through the year 2021/2022 to construct and develop a simplified peanut shelling machine in a private workshop in Fariskour city, and the Agricultural and Biosystems Engineering Department, Faculty of Agriculture, Damietta University, Egypt. The samples of peanut pods were bought from the local markets in Kafr Saad city, Damietta Governorate after the harvesting season of 2021.

### 2.1. MATERIALS

#### 2.1.1. The used crop

Peanut variety of (Giza-11) was used in this study with a primary moisture content of about 18% w.b. The samples were dried naturally under the sunshine to remove the moisture gradually. Some physical and mechanical properties of the peanut variety used in this study are shown in Table 1.

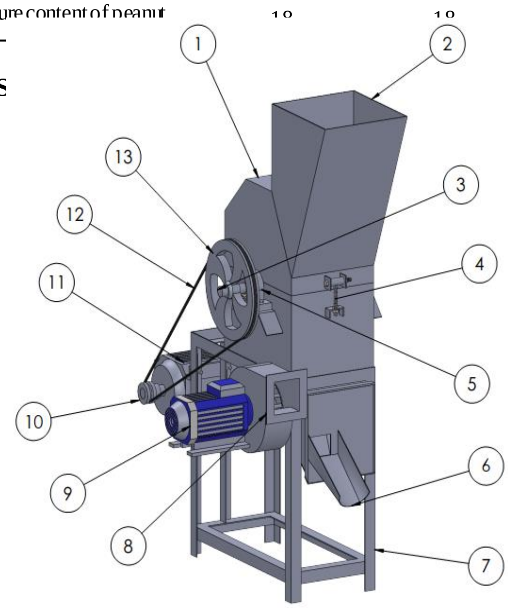
#### 2.1.2. Peanut shelling machine

The peanut shelling machine was developed, manufactured, and evaluated technically. Fig. 1 shows photos of the peanut shelling machine and Fig. 2 shows a general 3D drawing of the peanut shelling machine. The construction of the peanut shelling machine consists of the following parts:

**Table 1. Some physical and mechanical properties of peanut (Giza-11).**

| Item | Peanut kernel | Peanut pod | Unit |
|---|---|---|---|
| AV. Length | 21 | 42.71 | mm |
| AV. Width | 10.5 | 15.52 | mm |
| AV. Thickness | 8.5 | 14.11 | mm |
| AV. Volume | 981.35 | 4894.7 | $mm^3$ |
| Mass of 100 peanut | 86 | 243.23 | g |
| Arithmetic mean diameter | 13.33 | 24.11 | mm |
| Geometric mean diameter | 12.32 | 21.07 | mm |
| Sphericity | 58 | 49 | % |
| Flat surface area | 173 | 520.34 | $mm^2$ |
| Transverse surface area of the seed | 418.7 | 1369.32 | % |
| Moisture content of peanut | 18 | 18 | % |

**Fig. 1. S... machine.**



| No. | Part name | No. off |
|---|---|---|
| 1 | Shelling chamber | 1 |
| 2 | Machine hopper | 1 |
| 3 | Drum shaft | 1 |
| 4 | Screw bolt | 1 |
| 5 | Bearing | 2 |
| 6 | Output opening | 1 |
| 7 | Machine frame | 1 |
| 8 | Blower | 1 |
| 9 | Blower motor | 1 |
| 10 | Motor pulley | 3 |
| 11 | Machine motor | 1 |
| 12 | V-Belt | 1 |
| 13 | Drum Pulley | 1 |

**Fig. 2. 3D drawing of the developed shelling machine.**

**(a) Machine hopper:**

The hopper was made of iron steel with a total height of 45cm and has two openings; the upper one was established to receive peanut pods with dimensions of (32×27cm) in length and width, respectively; the lower one with dimensions of (27×22 cm) in length and width, respectively established to control the feeding rate of peanuts into the shelling chamber. Also, the sides of this hopper are gradually sloped with an inclination angle of (60°) from the horizontal to allow the peanut to flow at an appropriate feed rate from the hopper to the shelling chamber. The feeding process of the shelling machine is manually controlled with a sliding gate installed at the lower hopper opening. The sliding gate is made of steel sheet with dimensions of (26×24×0.2cm) in length, width, and thickness.

**(b) Shelling chamber:**

The shelling peanut machine chamber has three main parts as follows:

**• Shelling drum:**

The shelling drum is made of wooden material and covered with 13 rubber strips with a thickness of 1 cm and a length of 22 cm. The shelling drum diameter is 22 cm. This drum is fixed to the shelling shaft by four screws.

**• Drum shaft:**

The central shaft is located longitudinally inside the cylinder; it is made of steel with an outer diameter of 2.5 cm according to the shaft design made before manufacturing. The length of the shaft was 60 cm and it was supported by two bearings on both end sides.

**• The lower part: (serves as a concave):**

The bottom of the shelling chamber is a steel sieve. The grid was designed using Auto CAD software with dimensions of (26.5×45×0.2cm) for length, width, and thickness, respectively. The dimensions of each hole were (11×22.5mm) determined according to the physical and mechanical properties of peanut (Giza-11) and was drilled to allow only peeled and husked peanut to pass through the concave holes. The clearance between the shelling drum and the concave was (20 mm) determined also according to the physical and mechanical properties of peanut (Giza-11).

**(c) Cleaning unit:**

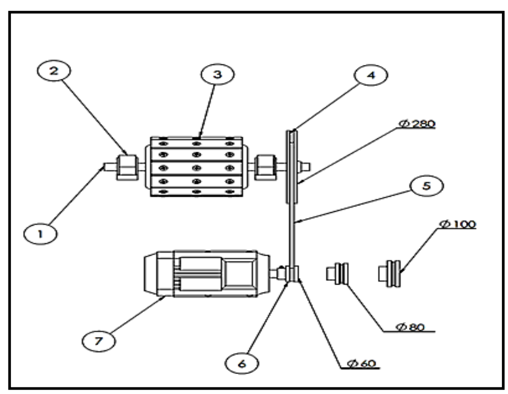
The cleaning unit was formed to separate peanut from husks using an intensive suction air stream at critical air speed for peanut kernels of (10.6m/s). The suction air stream was generated using a blower made of sheet metal with an outer diameter of 14 cm. It is powered by an electric motor with 0.25hp (186 W) at a maximum rotating speed of 2850 rpm. The blower is fixed at the end of the cleaning chamber to give the intensive suction stream which delivers all peanut husks to exit from its outlet, and the cleaned peanut kernels fall into the discharge outlet.

**(d) Peanut discharge:**

The shelled peanut moves towards the outlet opening where the direction has been made for the hulled and husked peanut, so that peanut pass next to the blower gate which is fixed at the end of the outlet opening to obtain the intensive air suction force resulting in high separation efficiency. The outlet opening is designed with a 40° horizontal inclination to facilitate moving hulled peanut in the direction of gravity.

**(e) Power transmission:**

The machine was powered by an electric motor of 1 hp (0.735kW) at a maximum rotating speed of 1400 rpm. The electric motor transmits its rotational movement to the drum shaft using V-belt and two pulleys; the small one is located at the motor shaft with changeable diameters of (6, 8 and10cm), while the large one is located at the shelling shaft with a constant diameter of (28cm), as shown in Fig. 3.




| No. | Part name | No. off | No. | Part name | No. off |
|---|---|---|---|---|---|
| 1 | Drum shaft | 1 | 5 | V-Belt | 1 |
| 2 | Bearing | 2 | 6 | Motor pulley | 3 |
| 3 | Drum | 1 | 7 | Machine motor | 1 |
| 4 | Drum Pulley | 1 | | **Dimensions in, mm** | |

**Fig.3. Power transmission from electrical motor to shelling shaft.**

**(f) Machine frame:**

The main frame of peanut shelling machine is constructed from steel bars. It includes elements to fix the electrical motor, the shelling chamber and its components, the cleaning unit, and the power transmission system. The shelling machine is fixed on the ground by four steel arms with dimensions of (30×60 mm) for width and length, with a total height of 60 cm.

**2.1.3. Design of peanut shelling shaft:**

The peanut shelling shaft is supported by two bearings. The first bearing is located beside the large pulley on the shelling shaft, and the second one locating at the end of the shelling shaft behind the shelling chamber. Two loads are affecting the shelling shaft. The first load ($F_1$) was transported from the mass of the drum pulley, the tension on the tight side of the v-belt, and the tension on the slack side. The second load ($F_2$) was due to the maximum hopper mass with peanuts and drum chains mass. These two loads are in different planes and directions, as shown in Fig. 4. The shelling shaft under these loads is subjected to combined torsion and bending stresses. The diameter of the shelling shaft can be calculated according to the maximum shear theory **(Khurmi and Gupta, 2007),** as following:

$$\tau_{max} = \frac{1}{2}\sqrt{\delta^2 + 4\,\tau^2} \text{ ..........(1)}$$

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{K_m{}^2 . Mb^2 + K_t{}^2 . T^2}\ , \quad kg/cm^2 \text{ ............(2)}$$

Where:

$\tau_{max}$ = Maximum shear stress = 450 $kg.cm^{-2}$

$\delta$ = Bending stress, $kg.cm^{-2}$

$\tau$ = Shear stress, $kg.cm^{-2}$

$M_b$ = Maximum bending moment, kg.cm

T = Maximum torque kg.cm

d = Diameter of shelling shaft, cm

$K_m$ = Shock factor for bending, $K_m$ = 2

$K_t$ = Shock factor for torsion, $K_t$ = 2

**1. Determination of maximum torque, ($T_{max}$):**

The maximum torque at the shelling shaft can be calculated from the motor horsepower and rotating speed as follows:

$$T_{max} = \frac{71640 HP}{N} = \frac{71640 \times 1}{300} = 238.8 \cong 240 \text{kg.cm} \text{ ................(3)}$$

Where:

HP = Motor power =1.0hp.

N = Minimum rotating speed for shelling shaft = 300rpm.

**2. Determination of maximum bending moment, ($M_{max}$):**

Maximum bending moment can be calculated from ($F_1$ and $F_2$) acting on the hollow shaft as follows:

**3. Determination of $F_1$:**

$F_1$ = Maximum weight of peanuts in the hopper and drum shaft weight = 5 + 2.5 = 7.5kg

**4. Determination of $F_2$:**

$$F_2 = T_1 + T_2 + W \text{............(4)}$$

Where:

$F_2$ = Tension force on pulley shaft, kg

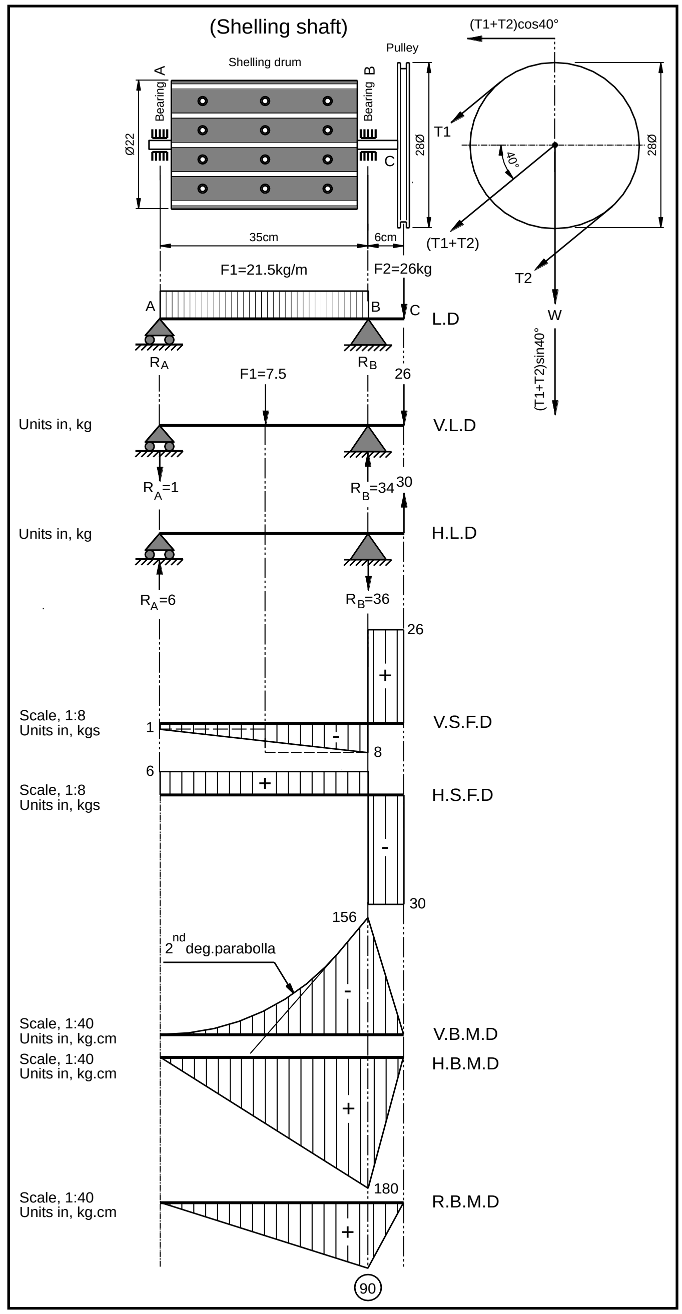



**Fig.4. Stress analysis on peanut shelling shaft.**

$T_1$ = Tension on the tight side of the belt, kg

$T_2$ = Tension on the slack side of the belt, kg

W = Weight of pulley, kg

$$\because T_m = 240 \text{ kg/cm}^2$$

$$T_m = (T_1 - T_2).r \therefore (T_1 - T_2) = \frac{240}{14} = 17.14 \ldots\ldots(5)$$

Where: $T_m$ = Torque at pulley shaft, kg.cm

r = Pulley radius = 14cm

$$\because \text{Ratio of tensions on the belt} = 2.3\log(\frac{T_1}{T_2}) = \mu\theta\cos\alpha \ldots\ldots(6)$$

Where: $\mu$ = Coefficient of friction, 0.3

$\theta$ = Angle of contact, rad

$\alpha$ = Groove angle of pulley, 40°

$$\because \theta = [(180 - (2\alpha)]\pi/180 \ldots\ldots(7)$$

$$\therefore \theta = [(180 - (2 \times 40)]3.14/180 = 1.74 \text{ rad}$$

$$\because 2.3\log(\frac{T_1}{T_2}) = 0.3 \times 1.74 \times \cos 40^o \ldots\ldots(8)$$

$$\frac{T_1}{T_2} = e^{2.3\times 0.422} \quad \therefore \frac{T_1}{T_2} = 2.64 \quad \& \quad T_1 = 2.64T_2 \ldots\ldots(9)$$

From equation (6) and (10), we get the follows:

$$\therefore T_1 = 27.60\text{kg} \quad \& \quad T_2 = 10.45\text{kg} \ldots\ldots(10)$$

**5. Determination of (f2v) at vertical direction:**

$$\because F_2V = (T_1 + T_2)\sin 40^\circ + W$$

$$\therefore F_2V = 24.46 + 1.6 = 25.76 \approx 26\text{kg} \ldots\ldots(11)$$

**6. Determination of (f2h) at horizontal direction:**

$$\because F_2H = (T_1 + T_2)\cos 40^\circ$$

$$\therefore F_2H = 29.15 \approx 30\text{kg} \ldots\ldots(12)$$

**7. Determination vertical reactions:**

By using the loading diagram in Fig.4. The reactions on bearing shaft ($R_A$) and ($R_B$) with vertical direction can be calculated as following:

$$\because \sum M \text{ at } B = 0$$

$$\therefore (R_A \times 35) + (26 \times 6) = (7.5 \times 17.5)$$

$$35R_A = -24.75 \quad \therefore R_A = -0.7 \approx 1\text{kg} \downarrow \ldots\ldots(13)$$

$$\& \because \sum Y = 0$$

$$\therefore R_B = 7.5 + 26 + 0.7 \quad \therefore R_B = 34.20 \approx 34\text{kg} \uparrow \ldots\ldots(14)$$

**8. Determination of horizontal reactions:**

By using the loading diagram in fig.4, the reactions on bearing shaft ($R_A$) and ($R_B$) with horizontal direction can be calculated as following:

$$\because \sum M \text{ at } B = 0$$

$$\therefore (R_A \times 35) = (30 \times 6)$$

$$\therefore R_A = 5.12 \approx 6\text{kg} \uparrow \ldots\ldots(15)$$

$$\& \because \sum Y = 0$$

$$\therefore R_A + R_B + 30 = 0 \quad \therefore R_B = -36\text{kg} \downarrow \ldots\ldots(16)$$

**9. Determination of vertical moments on bearing shaft:**

$$M_A = 0.0\text{kg.cm}$$

$$M_B = -(26 \times 6) = -156\text{kg.cm}$$

$$M_C = 0\text{kg.cm}$$

**10. Determination of the horizontal moments on shelling shaft:**

$$M_A = 0.0\text{kg.cm}$$

$$M_B = \sqrt{(-156)^2 + (180)^2} = 89.8 \approx 90\text{ kg.cm} \ldots\ldots(17)$$

$$M_C = 0\text{kg.cm}$$

**11. Determination of resultant moments on shelling shaft:**

$$M_A = 0.0\text{kg.cm}$$

$$M_B = 30 \times 6 = 180\text{kg.cm}$$

$$M_C = 0\text{kg.cm}$$

So, from Fig.4. The maximum bending moment on the shelling shaft equal $M_{Max}$= (90kg.cm). Then the maximum shear theory is applied as follows:

$$Z_{max} = \frac{16}{\pi d^3}\sqrt{K_m^2\ M^2 + K_t^2\ T^2}$$

$$\therefore 300 = \frac{16}{3.14d^3}\sqrt{2^2 \times (240)^2 + 2^2 \times (90)^2}$$

$$\therefore 300 = \frac{16}{3.14d^3} \times 512.64$$

$$\therefore d^3 = 8.70 \quad \therefore d = 2.05\text{cm} \quad (\text{Was taken } 25\,mm) \ldots\ldots(18)$$

## 2.2. METHODS:

The main experiments were carried out to develop and evaluate the performance of the peanut machine.

### 2.2.1. Experimental conditions

Preliminary experiments were carried out to develop a local peanut shelling machine. The performance of the developed machine was experimentally measured under the following parameters:

1. Three feeding rates of 60, 90, and 120 kg/h.

2. Three peanut moisture contents of 8.96, 12 and 15.61%.

2. Three drum rotating speeds of 300, 400, and 500 rpm (3.45, 4.6, and 5.75 m/s).

## 2.3. MEASUREMENTS AND DETERMINATIONS

Evaluation of peanut shelling machine was performed taking into consideration the following indicators:

### 2.3.1. Determination of the crop's physical properties

A random sample of one hundred peanut was taken from (giza-11) variety to measure the length (l), width (w), and thickness (t). Peanut mechanical properties were measured using the following equations, **El-Raie *et al*. (1996).**

$$V = \frac{\pi}{6}\left(L.W.T\right), \text{mm}^3 \quad \ldots\ldots\ldots(19)$$

$$S = \frac{\sqrt[3]{L.W.T}}{L} \times 100, \% \quad \ldots\ldots(20)$$

$$D_g = \sqrt[3]{L.W.T}, \text{m} \quad \ldots\ldots\ldots\ldots (21)$$

$$D_a = \frac{\left(L+W+T\right)}{3}, \text{mm}\ldots\ldots(22)$$

$$A_f = \frac{\pi}{4} L.W, \text{mm}^2 \quad \ldots\ldots\ldots\ldots(23)$$

$$A_t = \frac{\pi}{4}\frac{\left(L+W+T\right)^2}{3}, \text{mm}^2 ..(24)$$

Where:

L= length (mm), W= width (mm), T= thickness (mm), V= volume (mm$^3$),

$D_g$= Geometric diameter (mm), $D_a$= Arithmetic diameter (mm), $S$= Sphericity (%), $A_f$ = Flat surface area (mm$^2$), $A_t$= Transverse surface area of the seed (mm$^2$).

### 2.3.2. Moisture content (%):

Peanut sample mass was measured using electrical balance before shelling each treatment. Moisture content (%) was estimated on wet bulb (w.b) according to the following equations:

$$\text{M.C.(wb)} = \frac{(\text{W}-\text{d})}{\text{W}}, \ (\%) \quad \ldots\ldots\ldots\ldots(25)$$

M.c. (wb) = percentage of moisture content, (%).

W = mass of wet sample, g.

D = mass of dry sample, g.

### 2.3.3. Machine productivity:

The machine productivity was calculated during the shelling operation according to the following formula given by **Nagesh *et al*. (2018).**

$$\text{M}_\text{P} = \frac{60\text{W}_\text{s}}{\text{T}}, \text{Mg/h} \ \ldots\ldots\ldots\ldots \quad (26)$$

Where:

$M_P$ = machine productivity, Mg/h

$W_S$= mass of shelled groundnut, Mg

T = operating time, min

### 2.3.4. Breakage percentage:

The breakage percentage (mechanically damaged peanut) was determined according to the formula given by **Nagesh *et al*. (2018).**

$$B_r = \frac{\text{W}_\text{b}}{\text{W}_\text{s}}, \% \ \ldots\ldots\ldots \quad (27)$$

Where:

$B_r$= Breakage percentage, %.

$W_b$= Mass of broken peanut, kg

$W_s$= Mass of shelled peanut, kg

### 3.3.5. Shelling efficiency:

Shelling efficiency was determined according to the formula given by **Nagesh *et al*. (2018):**

$$\text{E}_\text{s} = 1 - \frac{\text{W}_\text{u}}{\text{W}_\text{t}} \times 100, \% \ \ldots\ldots\ldots\ldots \quad (28)$$

Where:

$E_S$= Shelling Efficiency, %

$W_u$= Mass of unshelled groundnut, kg.

$W_t$ = Total Mass of groundnut feed in the machine, kg.

### 3.3.6. Cleaning efficiency:

It is the degree of cleanliness of the peanut expressed as ($\eta_C$). Cleaning efficiency was determined according to the formula by **Mohammed and Hassan (2012)**.

$$\eta_C = \frac{\text{W}_\text{p}}{\text{W}_\text{p} + \text{W}_\text{C}}, \% \ldots\ldots\ldots\ldots \quad (29)$$

Where:

$W_P$ = Mass of winnowed pod, kg.

$W_C$ = Mass of chaff that accompany the decorticated groundnut, kg.

### 3.3.7. Required power:

The following formula was used to estimate the required power, **Ashby (1988).**

$$\text{Po} = \frac{\sqrt{2}}{1000}\left(\text{I}.\nu.\cos\theta\right), \text{kW} \ \ldots\ldots\ldots\ldots \quad (30)$$

Where: Po = Required power, kW , I = Current intensity, Ampere , V = Voltage, (220 V) , $\cos\theta$ = Power factor (being equal to 0.85).

**3.3.8. Specific energy:**

The following formula was used to obtain the energy consumed:

$$SE = \frac{Po}{Mp}, kW.h/kg \;\ldots\ldots\ldots\ldots \quad (31)$$

**3.3.10. Operational cost:**

The operational cost required for the shelling operation was estimated using the following equation, **Awady *et al.* (1982)**.

$$C_{op} = \frac{C}{M_p}, L.E/Mg \;\ldots\ldots\ldots\ldots \quad (32)$$

Where: C = hourly cost, L.E/h

The hourly cost of shelling operation was determined using the following equation, **Awady (1978)**.

$$C = \frac{p}{h}\left(\frac{1}{a}+\frac{i}{2}+t+r\right)+\left(w.e\right)+\frac{m}{224}, L.E \;\ldots\ldots(33)$$

Where:

P = price of machine, L.E.

h = yearly working hours, h/year.

a = life expectancy, h.

i = interest rate/year.

t = taxes, over heads ratio.

r = repairs and maintenance ratio.

W = power of motor in kW.

m = monthly average wage, L.E.

e = hourly cost/kW.h

224= monthly working hours.

## 3. RESULTS AND DISCUSSION

The obtained results will be discussed under the following items:

### 3.1. Effect of some operating parameters on machine productivity:

Results in **Fig.5** show the effect of feeding rate on machine productivity. Increasing feed rate from 60 to 120 kg/h under different moisture contents of 8.96, 12, and 15.61% and various drum rotating speeds of 300, 400, and 500 rpm leads to increase machine productivity from 19.1 to 37.35, from 27.12 to 50.28 and from 24.76 to 40.2 kg /h; from 18.23 to 31.6, from 24.8 to 41 and from 23.4 to 39.11kg /h; and from 17.7 to 29.87, from 23.8 to 40.19 and from 22.7 to 38.07 kg/h, respectively.

These results were due to the increased feeding rate of unseparated peanuts. The increased weight of the machine's feed rate caused an incomplete connection between the drum and the peanut. Increasing the time also increases the number of shelled peanut and thus increases productivity.

Concerning the effect of peanut moisture content on machine productivity, results in **Fig.5** show that increasing moisture content from 8.96 to 15.61% under different moisture contents feed rates of 60, 90, and 120 kg /h and various drum rotating speeds of 300, 400 and 500 rpm lead to increase machine productivity from19.1to 17.7, from 27.5 to 24.5, and from 37.35 to 29.78 kg/h; from 27.12 to 23.8, from 40.6 to 32.5, and from 50.28 to 40.19 kg/h; and from 24.76 to 22.7, from 37.6 to 29.91, and from 40.2 to 38.07 kg/h, respectively. The decrease in machine productivity is attributed to an increase in moisture content since the shell increases the moisture in it, making it tougher to shell and taking longer for shelling.

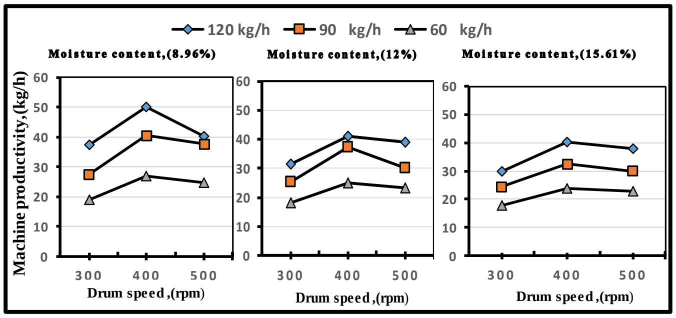



**Fig.5. Some operating parameters affecting on machine productivity.**

As to the effect of a drum rotating speed on machine productivity, Results in **Fig.5** show that increasing drum speed from 300 to 400 rpm under different moisture contents of 8.96, 12, and 15.61% and various feed rates of 60, 90 and 120 kg/h leads to increase machine productivity from 27.12 to 24.76, from 40.6 to 37.6 and from 50.28 to 40.2 kg/h; from 24.8 to 20.4, from 37.3 to 30.23 and from 41 to 39.11kg/h; and from 17.7 to 23.8, from 24.5 to 32.5, and from 29.87 to 40.19kg/h respectively. Any further increase in drum speed more than 400 up to 500 rpm measured at the same feed rates machine and different moisture contents decreased productivity from 27.12 to 24.76, from 40.6 to 37.6, and from 50.28 to 40.2 kg/h; from 24.8 to 20.4, from 37.3 to 30.23and from 41to 39.11kg/h; and from 23.8 to 22.7, from 32.5 to 29.91and from 40.19 to 38.07 kg/h, respectively.

The increase in machine productivity is due to increasing the speed of the drum from 300 to 400 rpm due to the short time spent in the shelling chamber at that time. The sieve slots are suitable for the exit of peanuts and husks, but with an increase in speed of 500 rpm, the exit time is shortened, and thus some slots become blocked, and the peeled peanut and husks are delayed, and thus the productivity decreases. This result is consistent with the findings of **Wijnands *et al.* (2009)**.

### 3.2. Effect of some operating parameters on breakage percentage:

Results in **Fig.6** show the effect of feeding rate on breakage percentage. Increasing feed rate from 60 to 120 kg/h under different moisture contents of 8.96, 12, and 15.61% and various drum rotating speeds of 300, 400, and 500 rpm leads to an increase in breakage percentage from 2.5 to 4.7, from 5.4 to from 6.8 and from 11 to 14%; from 2.4 to 3.8, from 3 to 5 and from13.5 to 14.8%; and from 2 to 3.3, from 2.5 to 4.1 and from 14 to 17.1%, respectively. The percentage of breakage increases with the increase in the feeding rate. This is due to the continuous supply of peanuts.

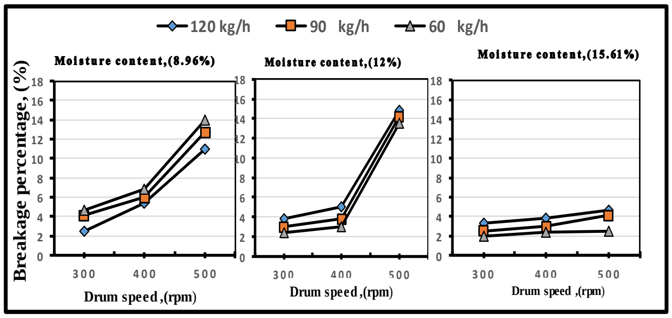



**Fig.6. Some operating parameters affecting on breakage percentage.**

It starts to happen that the husk and peanut come out from sieve holes, but some peanuts do not find holes to come out of, so the drum returns to press on it again and so on until it finds an exit for its exit.

Therefore, the higher rate of feeding gave a higher percentage of breakage. Concerning the effect of grain moisture content on breakage percentage, results in **Fig.6** show that increasing moisture content from 8.96 to 12% under different moisture contents feed rates of 60, 90, and 120 kg /h and drum rotating speed from 300 to 400 rpm leads to decrease breakage percentage from 2.5 to 2, from 4.1 to 2.5 and 4.7 to 3.3%; and from 5.4 to 2.5, 6 to 2.7 and 6.8 to 4.1%, respectively. Any further increase in moisture contents more than 12 up to 15.61% under different feed rates of 60, 90, and 120 kg /h and drum rotating speed from 400 to 500 rpm leads to an increase in breakage percentage from 11 to 14, 12.7 to 16 and 14 to 17.1%, respectively. The percentage of breakage decreases by increasing the moisture content, and this is because by increasing the moisture content, the peanuts are more resilient to the pressure of the drum and do not break easily at the speed from 300 to 400 rpm.

Although increasing the content reduces the percentage of breakage, the increase in speed to 500 rpm led to the lack of sufficient time for the exit of the peanuts and shells, and the shell dullness with the increase of moisture led to the passage of the drum many times until the exit from the concave holes, and thus the more moisture increases with a higher speed, the greater the percentage of breakage. As to the effect of a drum rotating speed on breakage percentage, Results in **Fig.6** show that increasing drum speed from 300 to 400 rpm under different moisture contents of 8.96, 12, and 15.61% and various feed rates of 60, 90 and 120 kg/h leads to increase breakage percentage from 2.5 to 11, from 4.1to 12.7 and 4.7 to 14%; from 2.4 to 13.5, from 3 to 14.2 and from 3.8 to 14.8%; and from 2 to 14, from 2.5 to 16 and from 3.3 to 17.1%, respectively. The percentage of breakage increases with the increase in the speed of the drum, and this is because, with the increase in the speed of the drum, and this is because, with the increase in the speed of the drum, the time for the peanuts and husks to come out will be shorter, which causes the peanuts to be compressed again until they come out of the concave holes, and thus the percentage of breakage increases. This result is consistent with the **Singh (1993).**

### 3.3. Effect of some operating parameters on shelling efficiency:

The shelling efficiency was 100% under three moisture content (8.96, 12, 15.61%) at different three drum speeds (3.45, 4.6, and 5.75 m/s) and three different feed rates (60, 90, 120 kg/h). Because there were no un-shelled peanuts and the whole shelled peanuts came out, designed the concave holes so that the largest shelled kernel could pass through and not the smallest un-shelled peanuts would pass through the same time from the holes. However, because atrophic peanuts are smaller than these holes, they will come out of the holes without being shelled. This ratio exceeded the ratio mentioned by **Iqbal *et al.* (2019)** for shelling efficiency which ranged more than 99 %.

### 3.4. Effect of some operating parameters on cleaning efficiency:

Results in **Fig.7** show the effect of feeding rate on cleaning efficiency. Increasing feed rate from 60 to 120 kg/h under different moisture contents of 8.96, 12, and 15.61% and various drum rotating speeds of 300, 400 and 500 rpm leads to decreased cleaning efficiency from 95 to 93.3, from 94 to 92.5 and from 94.5 to 93%; from 98.3 to 96.6, from 94.5 to 93.1 and from 95 to 93.7 %; and from 98.8 to 97, from 95.3 to 93.5 and from 96.6 to 94%, respectively.

The cleaning efficiency decreases as the feeding rate increases. This is because raising the feeding rate increases the number of shelled peanuts and husks that pass through the blower, reducing its capacity to suck out all the husks that come out and so decreasing cleaning efficiency.

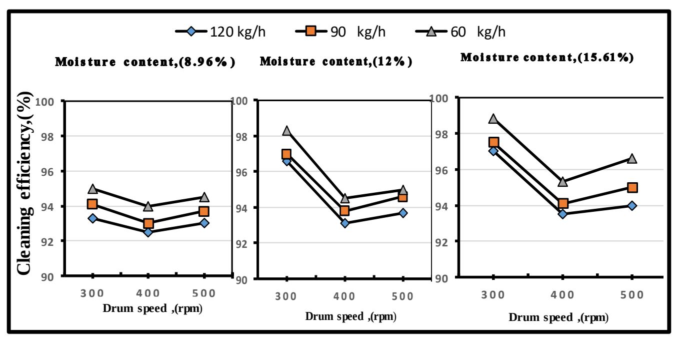



**Fig.7. Some operating parameters affecting on cleaning efficiency.**

Concerning the effect of peanut moisture content on cleaning efficiency, results in **Fig.7** show that increasing moisture content from 8.96 to 15.61% under different feed rates of 60, 90, and 120 kg /h and various drum rotating speeds of 300, 400 and 500 rpm leads to increase cleaning efficiency from 95 to 98.8, from 94.1to 97.5 and from 93.3 to 95.3%; from 94.2 to 95.3, from 93.5to 94.1and from 92.7 to 94.5%; and from 94.5 to 96.6, from 93.7 to 95 and from 93 to 94%, respectively. The cleaning efficiency increases when the speed decreases at 300 rpm due to low productivity as the number of peeled peanuts and husks that pass through the blower will be less, so the blower can suction most of the amount of the passing husks, but at the speed of 400 rpm it had the highest productivity as the husks and flaky peanuts passing through the blower increased, so the suction power It was lower and had the lowest cleaning efficiency. As for the speed at 500rpm, the amount of husk and peanuts passing on the blower was on average, and therefore the cleaning efficiency was medium. As to the effect of a drum rotating speed on cleaning efficiency, Results in **Fig.7** show that increasing drum speed from 300 to 400 rpm under different moisture contents of 8.96, 12, and 15.61% and various feed rates of 60, 90, and 120 kg/h leads to decrease cleaning efficiency from 95 to 94, 94.1 to 93, and 93.3 to 92.5%; from 98.3 to 94.5, 97 to 93.8, and 96.6 to 93.1%; and from 98.8 to 95.3, 97.5 to 94.1, and 97 to 93.5%, respectively. Any further increase in drum speed more than 400 up to 500 rpm measured at the same feed rates machine and different moisture contents increased productivity from 94 to 94.5, from 93 to 93.7.1and from 92 to 93%; from 94.5 to 95, from 93.8 to 94.6 and from 93.1 to 93.7%; and from 95.3 to 96.6, from 94.1to 95and from 93.5 to 94 %, respectively.

The cleaning efficiency increases with an increase in the moisture content because increasing peanut moisture content, the productivity decreases, and the peanuts with husks passing through the blower become less. This result is consistent with the findings of **Ghanem and Shetawy (2009).**

**3.5. Effect of some operating parameters on specific energy:**

Results in **Fig.8** show the effect of feeding rate on specific energy. Increasing feed rate from 60 to 120 kg/h under different moisture contents of 8.96, 12, and 15.61% and various drum rotating speeds of 300, 400, and 500 rpm leads to a decrease in specific energy from 26.28 to 13.4, from18.5to 9.98 and from 20.27 to 12. 48kW.h/Mg; 27.53 to 15.88, 20.24 to 12.24 and 21.45 to 12.83 kW.h/Mg; and 28.3 to 16.85, 21.09 to 12.5 and 22.11to 13.18 kW.h/Mg, respectively. The specific energy decreases with the increase in the rate of feeding because the increase in the rate of feeding increases productivity.

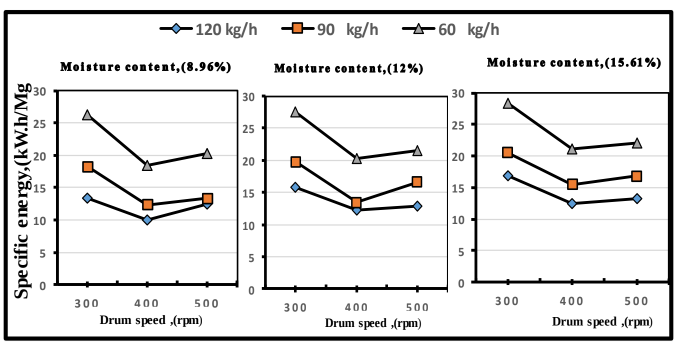



**Fig.8. Some operating parameters affecting on specific energy.**

Concerning the effect of peanut moisture content on specific energy, results in **Fig. 8** show that increasing moisture content from 8.96 to 15.61% under different moisture contents feed rates of 60, 90, and 120 kg /h and various drum rotating speeds of 300, 400 and 500 rpm leads to increase specific energy from 26.28 to 28.3, from 18.25 to 20.5 and from 13.44 to 16. 85 kW.h/Mg; from 18.5 to 21.09, 12.36 to 15.44, and 9.98 to 12. 5 kW.h/Mg; and from 20.27 to 22.11, 13.35 to 16.78 and 13.18 to 13. 18 kW.h/Mg, respectively. The specific energy increases with the increase in the moisture content because the increase in the moisture content decreases productivity.

As to the effect of a drum rotating speed on cleaning efficiency, Results in **Fig.8** show that increasing drum speed from 300 to 400 rpm under different moisture contents of 8.96, 12, and 15.61% and various feed rates of 60, 90 and 120 kg/h leads to decrease specific energy from26.28 to 18.5, from 18.25 to12.36, and from 13.44 to 9. 98 kW.h/Mg; from 27.53 to 20.24, from 19.77 to 13.45, and from 15.88 to 12.24 kW.h/Mg; and from 28.3 to 21.09, from 20.5 to 15.44, and from 16.85 to 12.5 kW.h/Mg, respectively. respectively. Any further increase in drum speed more than 400 up to 500 rpm measured at the same feed rates machine and different moisture contents increased specific energy from 18.5 to 20.27, from 12.36 to 13.35, and from 9.98 to 12.48 kW.h/Mg; from 20.24 to 21.45, from13.45 to 16.6 and from 12.24 to 12.83 kW.h/Mg; and from 21.09 to 22.11, from 15.44 to 16.78 and from 12.5 to 13.18 kW.h/Mg, respectively. The specific energy tends to increase as drum speed is increased above optimal values due to decreased machine productivity. These values considered acceptable even though they exceed the recommended values of **Helmy *et al.* (2007).** This may attribute to small machine productivity.

**3.6. Effect of some operating parameters on operational cost:**

Results in **Fig.9** show the effect of feeding rate on operational cost. Increasing feed rate from 60 to 120 kg/h under different moisture contents of 8.96, 12, and 15.61% and various drum rotating speeds of 300, 400, and 500 rpm lead to decrease operational cost from 902 to 461, 635 to 343, and 695 to 429 L.E/Mg; from 945 to 545, 694 to 420 and 736 to 440L.E/Mg; and from 973 to 578, 724 to 418 and 759 to 452L.E/Mg, respectively. The operational cost decreases with the increase in feeding rate resulting increase in productivity.

Concerning the effect of peanut moisture content on operational cost, results in **Fig.9** show that increasing moisture content from 8.96 to 15.61% under different moisture contents feed rates of 60, 90, and 120 kg /h and various drum rotating speeds of 300, 400 and 500 rpm leads to increase the operational cost from 902 to 973, from 626 to 703 and from 461 to 578 L.E/Mg; from 635 to 724, from 424 to 530 and from 343 to 418 L.E/Mg; and from 695 to 759, 458 to 576 and 429 to 452 L.E/Mg. The operational cost increases with the increase in the moisture content because the increase in the moisture content decreases productivity.

As to the effect of a drum rotating speed on operational cost, Results in **Fig.9** Increasing drum speed from 300 to 400 rpm under different moisture contents of 8.96, 12, and 15.61% and various feed rates of 60, 90 and 120 kg/h lead to decrease operational cost from 902 to 635, 626 to 424, and 461 to 343

L.E/Mg; 945 to 694, 678 to 461, and 545 to 420 L.E/Mg; and 724, 703 to 530, and 578 to 418L.E/Mg, respectively.

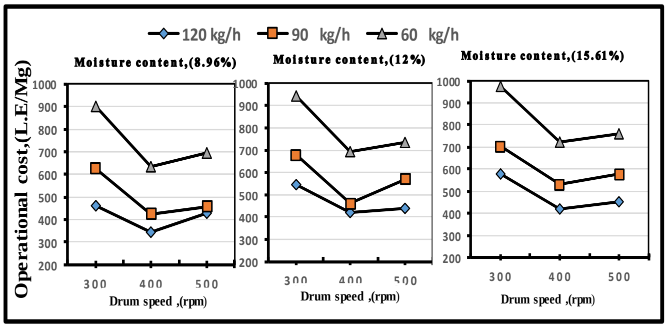



**Fig.9. Some operating parameters affecting on operational cost.**

Any further increase in drum speed more than 400 up to 500 rpm measured at the same feed rates and different moisture contents increased operational cost from 635 to 695, from 424 to 458, and from 343 to 429 L. E/Mg; from 694 to736, from 461 to 570 and from 420 to 440 L. E/Mg; and 724 to 759, 530 to 576 and from 418 to 452 L.E/Mg, respectively. The operational cost tends to increase as drum speed is increased above optimal values due to decreased machine productivity. These values considered acceptable despite the fact that they exceed the recommended values of **Helmy *et al.* (2007).** This may attribute to small machine productivity.

## 4. CONCLUSION

A peanut shelling machine was locally manufactured and evaluated taking into consideration the following indicators: machine productivity, breakage percentage, shelling efficiency, cleaning efficiency, specific energy, and operational cost. The experimental results reveal that the highest value of machine productivity was 50.28 kg/h while the lowest values of both specific energy and operational cost were 9.98 kw.h/mg and 343 l.e/mg were obtained at a drum speed of 400 rpm (4.6 m/s), moisture content of 8.96% and a feeding rate of 120 kg/h. The highest value of cleaning efficiency was 98.8%, while the lowest value of breakage percentage was 2%. These values were obtained at drum speed of 300 rpm (3.45 m/s), peanut moisture content of 15.61%, and feed rate of 60 kg/; and at a constant air speed of 10.6 m/s. The shelling efficiency was 100 % under all machine test runs.

## FUNDING:

This research did not receive any funding.

## CONFLICT OF INTEREST:

The authors declare that they have no conflict.

## AUTHORS CONTRIBUTION

EL-Sharabasy, M. M. A. and Hadeer R. A. El-Sharabasy developed the concept of the manuscript. Hadeer wrote the manuscript. EL-Sharabasy, M. M. A. checked and confirmed the final revised manuscript

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## الملخص العربي

## تصنيع وتقييم أداء آلـة مبسطة لتقشير الفول السوداني

**أ.د. مُحب محمد أنيس الشرباصي وهدير رضا الحميدي الشرباصي**

**قسم هندسة النظم الزراعية والحيوية ـ كلية الزراعة ـ جامعة دمياط**

يعتبر الفول السوداني من أهم المحاصيل البقولية في مصر والكثير من دول العالم، حيث يتم استخدامه للاستهلاك البشري والصناعات الغذائية (كمصدر للزيت والبروتين والكربوهيدرات) وتغذية الحيوانات وإنتاج النفط. وعلى الرغم من تطور التقشير الآلي للفول السوداني إلا أن الطرق التقليدية للتقشير لا تزال سائدة بسبب التكلفة العالية للآلات والصيانة اللاحقة وعدم توافر قطع الغيار وانخفاض كفاءة التقشير والنسبة العالية من الكسر وارتفاع تكاليف التشغيل. ولتقليل الوقت والجهد والتكاليف اللازمة لعملية التقشير اليدوي للفول السوداني فقد تم تطوير وتصنيع آلة محلية لتقشير الفول السوداني بورشة خاصة بمدينة فارسكور وقسم هندسة النظم الزراعية والحيوية بكلية الزراعة ـ جامعة دمياط بهدف تحقيق التنمية الاقتصادية بأقل تكلفة ممكنة.

**وكانت أهداف الدراسة الآتي:**

- تصنيع وتقييم أداء آلة محلية الصنع تناسب تقشير الفول السوداني.
- تحديد القيم التشغيلية المثلى لكل من معدلات التلقيم وسرعة الدرفيل ونسب المحتوى الرطوبة التي تحقق أعلي كفاءة بأقل تكلفة لتشغيل الآلة.
- تقييم الآلة المصنعة محلياً من المنظور الاقتصادي.

**وقد أجريت التجارب العملية باستخدام المعاملات الآتية:**

- ثلاث سرعات مختلفة لدرفيل التقشير وهي: 500.400.300 لفة/ دقيقة عند سرعة محيطية (3.45، 4.6 و5.7 م/ث).
- ثلاث نسب رطوبة مختلفة للفول السوداني وهي: 8.96، 12 و15.61 ٪.
- ثلاث معدلات تلقيم مختلفة وهي: 60، 90 و120 كجم/ ساعة.

ولتقييم أداء آلة تقشير الفول السوداني المصنعة محلياً تم أخذ القياسات التالية: (إنتاجية الآلة، نسبة الكسر وكفاءة التقشير وكفاءة التنظيف وكذلك الطاقة المستهلكة مع حساب تكاليف التشغيل).

**وقد أظهرت النتائج المتحصل عليها ما يلي:**

- أقل نسبة كسر وأقصي قيمة لكفاءة التنظيف كانت 2٪ و98.8٪، على الترتيب. عندما سرعة درفيل 300 لفة/ دقيقة (3.45متر/ثانية) ونسبة رطوبة 15.61٪ ومعدل تلقيم 60 كجم/ساعة وعند سرعة هواء ثابتة 10.6متر/ ثانية.
- أعلي إنتاجية للآلة مع أقل قيمة للطاقة المستهلكة مع أقل قيمة لتكاليف تشغيل الآلة المصنعة كانت 50.28 كجم/ساعة و9.98 كيلووات. ساعة/ ميجاجرام و343 جنيه/ميجاجرام)، على الترتيب. عند سرعة درفيل 400 لفة/دقيقة (4.6 متر/ثانية) ونسبة رطوبة 8.96٪ ومعدل تلقيم 120كجم/ساعة.

ومن ثم توصي الدراسة باستخدام آلة تقشير الفول السوداني المصنعة محلياً للحصول على أعلى إنتاجية بكفاءة عالية وبأقل طاقة مستهلكة مع أقل تكاليف تشغيل عند الظروف التالية:

- معدل التلقيم (120 كجم/ساعة).
- سرعة درفيل التقشير (400 لفة/دقيقة) أو (4.6 متر/ثانية).
- محتوى رطوبة المحصول (8.96٪).
- سرعة ثابتة لهواء التنظيف (10.6متر/ ثانية).

**الكلمات المفتاحية:** الفول السوداني، التقشير، الكفاءة، الطاقة، التكلفة التشغيلية.

DJAS., Volume (2), Issue (I), 2023